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TOWNSEND and TOWNSEND and CREW LLP

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PATENT
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Hemant P. Mungekar et al.

Application No.: 10/660,813

Filed: September 12, 2003

For: Reactive Ion Etching For
Semiconductor Device Feature
Topography Modification

Customer No.: 57385

Confirmation No.: 7055

Examiner: Rodney Glenn McDonald

Art Unit: 1795

AMENDED APPELLANTS' BRIEF
UNDER 37 C.F.R. § 41.37

Mail Stop Appeal Brief
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Further to the "Notification Of Non-Compliant Appeal Brief" mailed on July 18, 2008, for the above-referenced application, Appellant submits this Amended Brief on Appeal.

1. Real Party In Interest

Applied Materials, Inc., of Santa Clara, California, is the real party in interest as the assignee of the above-identified application.

2. Related Appeals And Interferences

No other appeals or interferences are known that will directly affect, are directly affected by, or have a bearing on the Board decision in this appeal.

3. Status Of Claims

Claims 1-28 are currently pending in the application. All pending claims stand finally rejected pursuant to a final Office Action mailed January 4, 2008. A copy of the claims as rejected is attached as Appendix A.

Claims 1-5, 7, 11-15, 17, 18, 20-24, 26 and 27 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,846,745 to Papasouliotis et al. ("Papasouliotis '745") in view of U.S. Patent No. 6,596,654 to Bayman et al. ("Bayman"). This rejection is the subject of the appeal.

Claims 6 and 8-10 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Papasouliotis '745 in view of Bayman as applied to claims 1-5, 7, 11-15, 17, 18, 20-24, 26 and 27, and further in view of U.S. Patent No. 5,756,402 to Jimbo et al. ("Jimbo"). Claims 16, 19, 25 and 28 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Papasouliotis '745 in view of Bayman as applied to claims 1-5, 7, 11-15, 17, 18, 20-24, 26 and 27, and further in view of U.S. Patent No. 6,794,290 to Papasouliotis et al. ("Papasouliotis '290"). These rejections are not the subject of the appeal. Appellants do not, however, concede the rejection of these claims.

4. Status Of Amendments

The claims have been amended three times. An Amendment was filed on November 28, 2005, in response to a non-final Office Action mailed September 21, 2005. An Amendment was filed on March 29, 2006, in response to a final Office Action mailed February 14, 2006. An Amendment was filed on October 9, 2006, in response to a non-final Office Action mailed July 19, 2006. No amendments have been entered subsequent to the final Office Action mailed January 4, 2008. This Appeal Brief is filed in response to the final Office Action.

5. Summary Of Claimed Subject Matter

In the following summary, the Appellants have provided exemplary references to sections of the specification and drawings supporting the subject matter defined in the claims as required by 37 C.F.R. § 41.37. The specification and drawings also include additional support for other exemplary embodiments encompassed by the claimed subject matter. Thus, it should be appreciated that the references are intended to be illustrative in nature only.

Claim 1 is generally directed towards a method for depositing a silicate glass film on a substrate disposed in a substrate processing chamber, the substrate having a trench formed between adjacent raised surfaces. Application, p. 3, ll. 7-9. The method includes depositing a first portion of the silicate glass film over the substrate from a first gaseous mixture flowed into the processing chamber by chemical-vapor deposition. Id., p. 3, ll. 9-10. Thereafter, etching the first portion by flowing an etchant gas comprising a halogen precursor, a hydrogen precursor, and an oxygen precursor into the process chamber. Id., p. 3, ll. 11-12. The halogen precursor being flowed into the processing chamber at a flow rate between 10 and 1000 sccm and the hydrogen precursor being flowed into the processing chamber at a flow rate greater than 100 sccm to control chemical interaction between the halogen precursor and the hydrogen precursor to provide a desired etch rate. Id., p. 26, Table I entitled "Exemplary Ranges For Process Parameters," see row for "NF₃ flow [sccm]" and "H₂ flow [sccm]." As described on p. 3, ll. 18-21, the halogen precursor may include NF₃. Thereafter, depositing a second portion of the silicate glass film over the substrate from a second gaseous mixture flowed into the processing chamber by chemical-vapor deposition. Id., p. 3, ll. 13-14.

Claim 20 is directed towards a method for depositing a silicate glass film on a substrate disposed in a substrate processing chamber, the substrate having a trench formed between adjacent raised surfaces. Id., p. 4, ll. 4-6. The method includes depositing a first portion of the silicate glass film over the substrate by forming a plasma from a first gaseous mixture flowed into the processing chamber, the first gaseous mixture comprising a silicon-containing gas and an oxygen-containing gas. Id., p. 4, ll. 6-7; p. 26, Table I entitled "Exemplary

Ranges For Process Parameters.” Thereafter, etching the first portion by forming a plasma from an etchant gas mixture flowed into the processing chamber. *Id.*, p. 4, ll. 8-9. The etchant gas mixture comprising a fluorine-containing gas, H₂, and O₂. *Id.*, p. 26, Table I entitled “Exemplary Ranges For Process Parameters.” The fluorine-containing gas is flowed into the processing chamber at a flow rate between 10 and 1000 sccm and the H₂ is flowed into the processing chamber at a flow rate greater than 100 sccm. *Id.* Thereafter, depositing a second portion of the silicate glass film over the substrate by forming a plasma from a second gaseous mixture flowed into the processing chamber. *Id.*, p. 4, ll. 12-13. The second gaseous mixture comprising the silicon-containing gas and the oxygen-containing gas. *Id.*, p. 26, Table I entitled “Exemplary Ranges For Process Parameters.”

Claim 26 is directed towards a method for depositing a silicate glass film on a substrate disposed in a substrate processing chamber, the substrate having a trench formed between adjacent raised surfaces. *Id.*, p. 4, ll. 4-6. The method includes depositing a first portion of the silicate glass film over the substrate by forming a plasma from a first gaseous mixture flowed into the processing chamber. *Id.*, p. 4, ll. 6-8. Thereafter, etching the first portion by forming a plasma from an etchant gas mixture flowed into the processing chamber. *Id.*, p. 4, ll. 8-9. The etchant gas mixture comprising a first precursor gas reactive with the silicate glass film, a second precursor gas reactive with the first precursor gas, and an inert sputtering agent flowed into the processing chamber. *Id.*, p. 4, ll. 9-12. The first precursor gas being flowed into the processing chamber at a flow rate between 10 and 1000 sccm. *Id.*, p. 26, Table I entitled “Exemplary Ranges For Process Parameters.” The second precursor gas being flowed at a flow rate greater than 100 sccm to control chemical interaction between the first and second precursor gases to provide a desired etch rate. *Id.* The inert sputtering agent flowed at a respective flow rate to control relative isotropic and anisotropic contributions to the etching. *Id.*, p. 4, ll. 10-12. Thereafter, depositing a second portion of the silicate glass film by forming a plasma from a second gaseous mixture. *Id.*, p. 4, ll. 12-13.

6. Grounds Of Rejection To Be Reviewed On Appeal

Issue 1: Whether claims 1-5, 7, 11-15, 17, 18, 20-24, 26 and 27 were properly rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,846,745 to Papasouliotis et al. ("Papasouliotis '745") in view of U.S. Patent No. 6,596,654 to Bayman et al. ("Bayman").

7. Argument

Issue 1: Whether claims 1-5, 7, 11-15, 17, 18, 20-24, 26 and 27 were properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Papasouliotis '745 in view of Bayman.

To maintain a prima facie rejection under 35 U.S.C. § 103(a), the Examiner is charged with showing that the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious to a person having ordinary skill in the art. MPEP § 2141. Thus, each and every element of the claims must be taught or suggested in the cited prior art. In doing so, the analysis should be made explicit. MPEP § 2142. That is, a "rejection on obviousness cannot be sustained with mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness." *Id.*, quoting *KSR International Co. v. Teleflex Inc.*, 127 S.Ct. 1727, 1938, 82 USPQ2d 1385, 1396 (2007).

The claims recite a process that generally includes a deposition of a silicate glass, an etching of the silicate glass followed by another deposition of the silicate glass. The claims detail a specific etchant gas composition and flow rates for the etchant gas constituents. Specifically, the etchant gas comprises a halogen precursor, a hydrogen precursor, and an oxygen precursor. The halogen precursor is flowed into the processing chamber at a flow rate between 10 and 1000 sccm, and the hydrogen precursor is flowed into the processing chamber at a flow rate greater than 100 sccm.

The Office Action relies on Papasouliotis '745 for showing that most of the elements of the independent claims are taught or suggested, acknowledging, however, that Papasouliotis '745 does not teach or suggest a flow rate of a hydrogen precursor. Office Action, p. 5. Papasouliotis '745 generally discloses a process that includes a dielectric deposition, an etch followed by another dielectric deposition. Papasouliotis '745, FIG. 1B. As noted, Papasouliotis '745 does not teach or suggest that a hydrogen precursor is flowed into the processing chamber at a flow rate greater than 100 sccm during etching.

The Office Action relies on the disclosure of Bayman to show that claimed flow rate is obvious in conjunction with Papasouliotis '745. Bayman discloses a chemical vapor deposition process that involves the use of hydrogen in the deposition reactive mixture. Bayman, Abstract; col. 2, ll. 7-21; col. 3, ll. 39-45, etc. Specifically, Bayman describes introducing hydrogen during deposition with a flow rate greater than 400 sccm. Bayman is focused on the deposition of a dielectric on a substrate. Indeed, Bayman does not disclose etching or any processes related thereto, let alone etching with a specific flow rate of hydrogen.

In proposing this combination, the Office Action does not appear to account for the very different contexts in which these disclosures are made. Papasouliotis '745 discloses a dep/etch/dep process while Bayman is concerned only with a deposition process. The claim element reciting a flow rate for the hydrogen precursor refers to a flow rate during the etching phase of a dep/etch/dep process and is included in combination with halogen and oxygen precursors. What Bayman discloses is the use of a hydrogen precursor during a deposition process only. While it is true that the hydrogen acts as a sputtering agent that removes some material during deposition, this is a general characteristic of HDP processes. See Application, p. 2, ll. 13-16. Nothing in Bayman suggests in any way the use of a hydrogen precursor during a halogen-based etching process, and certainly not in combination with the other precursors recited in the claims as being used during the etching part of the process. At best, the teachings of Bayman might suggest the use of a hydrogen precursor as a sputtering agent during the deposition phases of the Papasouliotis '745 dep/etch/dep process. They certainly say nothing to one of skill in the art about the use of a hydrogen precursor during the etching phase of such a process.

There is a fundamental difference between a deposition process and an etching process. These two processes provide fundamentally opposite results. Deposition is a process whereby material is deposited on a substrate. Etching, on the other hand, is a chemical process used to remove portions of the material deposited during the deposition process. In other words, the material added by the deposition process is removed by the etching process. Thus, because of the significant opposed nature of these two processes, one skilled in the art would not consider a specific teaching in an etching process as an obvious inclusion in a deposition process and vice versa.

In explaining the basis for rejection, the Office Action takes the view that the disclosure of SiH_2F_2 as a potential precursor in Papasouliotis '745 for the etching phase of the process satisfies the claim elements requiring a flow of a halogen precursor and a flow of a hydrogen precursor. Applicants have no quarrel with such a view by itself, but note that the claims separately define limits on the specific flow rates of the halogen and hydrogen precursors. In proposing to incorporate the teachings of Bayman regarding the flow rate of the hydrogen precursor, there are two possibilities, neither of which is indicated by any teaching or suggestion in the prior art.

First, the Office Action might be suggesting that the SiH_2F_2 precursor be flowed at the 400 sccm rate taught by Bayman, but there is no basis to believe that a flow rate for H_2 in the context of the specific deposition processes taught by Bayman would be appropriate for a flow of an SiH_2F_2 precursor during an etching process, particularly when the flow of the SiH_2F_2 precursor also determines the flow of the halogen precursor.

Second, the Office Action might be suggesting that an H_2 precursor be flowed in addition to the SiH_2F_2 precursor, or perhaps in addition to one of the other fluorine precursors identified by Papasouliotis '745, but the fact that Bayman teaches the use of hydrogen as a sputtering agent during an HDP deposition process in no way suggests to one of skill in the art its suitability during a halogen etching process. The only recognition of the value of combining a halogen etch with a hydrogen flow is found in Applicants' disclosure, which recognizes not only the potential for diluent effects but also the potential for chemical interactions that result in a

process having both isotropic and anisotropic components. See Application, p. 9, l. 19 – p. 10, l. 14.

The combination of Papasouliotis '745 and Bayman does not teach or suggest inclusion of a hydrogen precursor at specified rates during the etching dep/etch/dep process as claimed in claims 1-5, 7, 11-15, 17, 18, 20-24, 26 and 27. Accordingly, these references do not render these claims obvious.

8. Conclusion

For these reasons, it is respectfully submitted that the rejection should be reversed.

Respectfully submitted,

Date: August 1, 2008

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9. Claims Appendix

1. (Previously Presented) A method for depositing a silicate glass film on a substrate disposed in a substrate processing chamber, the substrate having a trench formed between adjacent raised surfaces, the method comprising:

depositing a first portion of the silicate glass film over the substrate from a first gaseous mixture flowed into the processing chamber by chemical-vapor deposition;

thereafter, etching the first portion by flowing an etchant gas comprising a halogen precursor, a hydrogen precursor, and an oxygen precursor into the process chamber, with halogen precursor being flowed into the processing chamber at a flow rate between 10 and 1000 sccm and the hydrogen precursor being flowed into the processing chamber at a flow rate greater than 100 sccm to control chemical interaction between the halogen precursor and the hydrogen precursor to provide a desired etch rate; and

thereafter, depositing a second portion of the silicate glass film over the substrate from a second gaseous mixture flowed into the processing chamber by chemical-vapor deposition.

2. (Original) The method recited in claim 1 wherein the hydrogen precursor comprises H_2 .

3. (Original) The method recited in claim 1 wherein the halogen precursor comprises a fluorine precursor.

4. (Original) The method recited in claim 3 wherein the fluorine precursor comprises NF_3 .

5. (Original) The method recited in claim 4 wherein:
the substrate includes a silicon nitride layer; and
etching the first portion comprises adjusting a flow rate of the hydrogen precursor and a flow rate of the NF_3 to control a relative concentration of NO and F in the processing chamber.

6. (Original) The method recited in claim 3 wherein the fluorine precursor comprises F_2 .
7. (Original) The method recited in claim 3 wherein the fluorine precursor comprises SiF_4 .
8. (Original) The method recited in claim 1 wherein the hydrogen precursor and the oxygen precursor are comprised by a single compound.
9. (Original) The method recited in claim 8 wherein the single compound is H_2O .
10. (Original) The method recited in claim 8 wherein the single compound is H_2O_2 .
11. (Original) The method recited in claim 1 wherein etching the first portion comprises maintaining a plasma formed from the etchant gas.
12. (Original) The method recited in claim 11 wherein the plasma is a high-density plasma.
13. (Original) The method recited in claim 11 wherein the etchant gas further comprises an inert sputtering agent.
14. (Original) The method recited in claim 13 wherein the inert sputtering agent comprises Ar.
15. (Original) The method recited in claim 13 wherein the inert sputtering agent comprises He.
16. (Original) The method recited in claim 13 wherein etching the first portion is performed with a sputter/removal ratio between 0.0 and 0.8, the sputter/removal ratio corresponding to a ratio of a volume of material removed by sputtering to a total volume of material removed by a combination of sputtering and chemical etching.

17. (Original) The method recited in claim 11 wherein:
depositing the first portion of the film comprises maintaining a plasma formed from the first gaseous mixture; and
depositing the second portion of the film comprises maintaining a plasma formed from the second gaseous mixture.
18. (Original) The method recited in claim 11 further comprising biasing the plasma towards the substrate.
19. (Original) The method recited in claim 1 wherein etching the first portion comprises flowing the hydrogen precursor at different flow rates to different parts of the processing chamber to effect a radially nonuniform etching distribution over the substrate.
20. (Previously Presented) A method for depositing a silicate glass film on a substrate disposed in a substrate processing chamber, the substrate having a trench formed between adjacent raised surfaces, the method comprising:
depositing a first portion of the silicate glass film over the substrate by forming a plasma from a first gaseous mixture flowed into the processing chamber, the first gaseous mixture comprising a silicon-containing gas and an oxygen-containing gas;
thereafter, etching the first portion by forming a plasma from an etchant gas mixture flowed into the processing chamber, the etchant gas mixture comprising a fluorine-containing gas, H_2 , and O_2 , wherein the fluorine-containing gas is flowed into the processing chamber at a flow rate between 10 and 1000 sccm and the H_2 is flowed into the processing chamber at a flow rate greater than 100 sccm; and
thereafter, depositing a second portion of the silicate glass film over the substrate by forming a plasma from a second gaseous mixture flowed into the processing chamber, the second gaseous mixture comprising the silicon-containing gas and the oxygen-containing gas.
21. (Original) The method recited in claim 20 wherein the fluorine-containing gas comprises NF_3 .

22. (Original) The method recited in claim 21 wherein:
the substrate includes a silicon nitride layer; and
etching the first portion comprises adjusting flow rates of the NF_3 , H_2 , and O_2 to control a relative concentration of NO and F in the processing chamber.
23. (Original) The method recited in claim 20 wherein the etchant gas mixture further comprises an inert sputtering agent.
24. (Original) The method recited in claim 20 wherein etching the first portion further comprises biasing the plasma formed from the etchant gas towards the substrate.
25. (Original) The method recited in claim 20 wherein etching the first portion comprises flowing the H_2 at different flow rates to different parts of the processing chamber to effect a radially nonuniform etching distribution over the substrate.
26. (Previously Presented) A method for depositing a silicate glass film on a substrate disposed in a substrate processing chamber, the substrate having a trench formed between adjacent raised surfaces, the method comprising:
depositing a first portion of the silicate glass film over the substrate by forming a plasma from a first gaseous mixture flowed into the processing chamber;
thereafter, etching the first portion by forming a plasma from an etchant gas mixture flowed into the processing chamber, the etchant gas mixture comprising a first precursor gas reactive with the silicate glass film, a second precursor gas reactive with the first precursor gas, and an inert sputtering agent flowed into the processing chamber, with the first precursor gas being flowed into the processing chamber at a flow rate between 10 and 1000 sccm and second precursor gas being flowed at a flow rate greater than 100 sccm to control chemical interaction between the first and second precursor gases to provide a desired etch rate, and with the inert sputtering agent flowed at a respective flow rate to control relative isotropic and anisotropic contributions to the etching; and
thereafter, depositing a second portion of the silicate glass film by forming a plasma from a second gaseous mixture.

27. (Original) The method recited in claim 26 wherein etching the first portion further comprises biasing the plasma formed from the etchant gas towards the substrate.

28. (Original) The method recited in claim 26 wherein etching the first portion comprises flowing the second precursor gas to provide a different distribution within the processing chamber than the first precursor gas, thereby effecting a nonuniform etching distribution over the substrate.

10. Evidence Appendix

No additional evidence is provided.

11. Related Proceedings Appendix

No additional proceedings are in process.